South Florida Water Management District
Information Technology Division/Network Systems Engineering
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The Telemetry Backbone - The Journey from the Field to the Front End Processor

By

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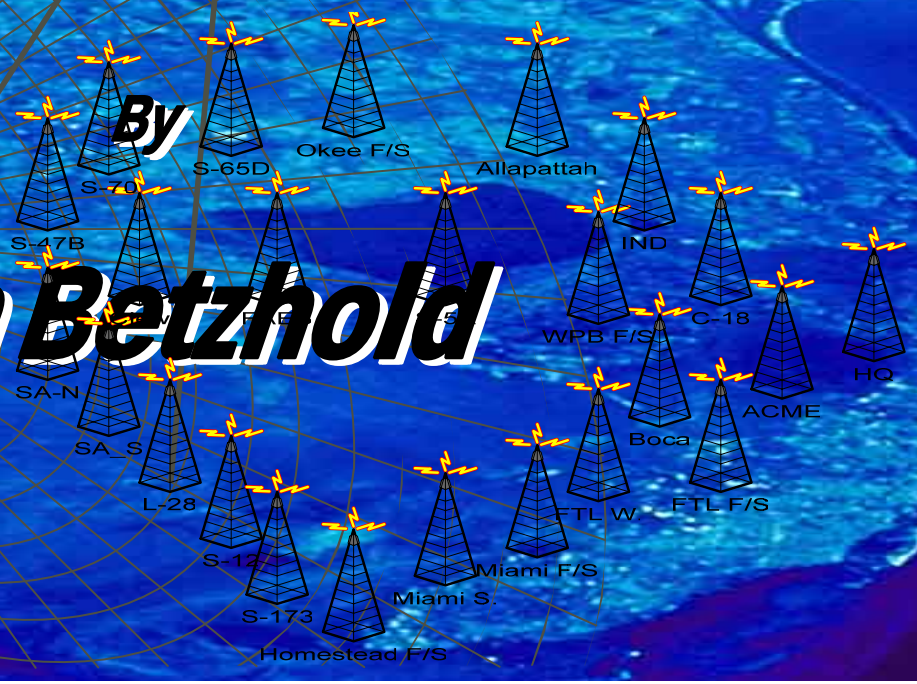


History

- Modern electronic flood control and remote monitoring began at the District in 1974.
- This flood control system allowed water managers to remotely control and monitor strategic flood gates and hydrologic conditions.
- The backbone of this telemetry system is a twenty-four station microwave infrastructure with two-way radio extensions.
- This recently modernized microwave communications infrastructure now supports voice radio relay, Supervisory Control and Data Acquisition (SCADA), telephone circuits/trunks and computer network traffic.
- The entire communications system was built and is currently maintained to withstand hurricane force winds of up to 150 miles per hour.

What Technologies are used to Transport SCADA Data from the Remote Sites to HQ?

- Hardwired (RS-232, RS-485, etc.)
- Telephone Lines (2-Wire, 4-Wire)
- Optical (Fiber Optic and Infrared)
- Satellite (Uplink and Bent Pipes)
- Cellular/PCS (CDPD, GPRS, CDMA)
- Radio Frequency (VHF, UHF, Spread Spectrum)
- Microwave (Licensed and Unlicensed)

Hardwired Transport

- Hardwired transports are limited to reasonable cable lengths and have inherent range limitations of less than 4000 feet (RS-485)
- RS-232, RS-422, RS-485 and SDI-12 communications links are utilized by the District to communicate between ‘smart’ devices (i.e. PLC’s and smart sensors)
- No Hardwired transports are used at the District to get data from the field back to the SCADA head end.

Telephone Lines

- Telephone lines are used by the District to collect data from non-flood control sites.
- Telephone modems require ‘negotiation’ times which greatly extend the poll and response time of a SCADA system.
- Telephone lines can be used to manage remote access for multiple users. A busy signal can keep simultaneous users from interfering with one another.
- The legacy C&C System utilizes 4-wire analog circuits for modem communications (1200 baud) to the central MODCOMP computer.

Optical Transports

- Optical transports offer relatively high reliability and the highest bandwidth per circuit.
- New Infrared technologies offer high bandwidth but limited range.
- The District does use fiber optic technologies to transport between buildings on some remote sites and at headquarters.
- Synchronous Optical NETwork (SONET) Technology is utilized on the District's microwave network and at HQ.
- SONET utilizes self healing ring based topologies that result in circuit re-routing in less than 50 milliseconds following a circuit interruption.

Satellite Transport

- Satellite Transport is not currently utilized by the District. We do currently support voice and telephony service via satellite.
- There are two methods of Satellite data communications: “Uplink” and “Bent Pipes”.
- Uplinks send data received by the satellite to a centralized earth station for distribution (usually dial-up or internet) This method results in long delays (several seconds) between query and response.
- Bent Pipes are an emerging satellite offering where the satellite beams the received data directly to a receiver at the customers location. This technology is more responsive but also much more expensive.
- Satellite communications are negatively impacted by clouds and solar flares. (A solar flare recently destroyed a satellite deployed by Japan)

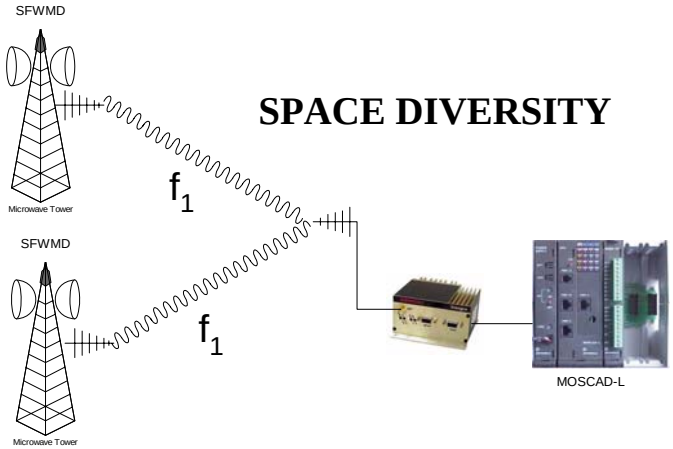
Cellular/PCS Transport

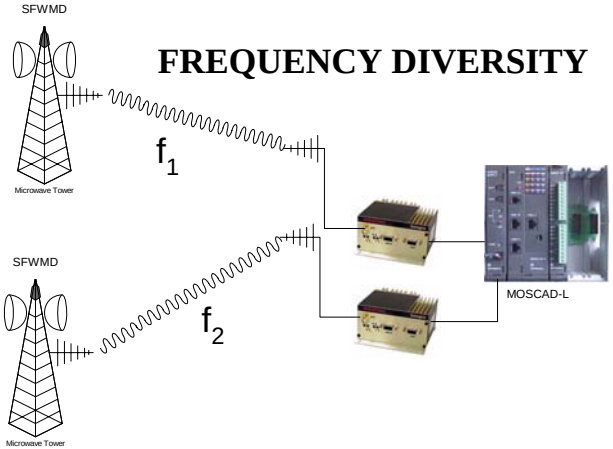
- Cellular/PCS transport is utilized by some of the District's monitoring systems.
- Cellular data collection requires a redistribution of data from a central station (similar to satellite). This redistribution is typically done via an internet connection.
- Cellular dependency on the internet and the resulting transport delays make it unsuitable for critical command and control use.

Radio Frequency Transport

- The District extensively utilizes radio frequency based technologies for data transport.
- Radio Frequency (RF) based communications can be designed to be very reliable and as it is a technology owned by the end user the responsiveness and availability can be mediated.
- The District utilizes VHF, UHF and Spread Spectrum two way radios on monitoring and critical command and control sites.
- RF communications are typically slower (1200 baud to 9600 baud). Recently developed modulation schemes and spread spectrum technologies are achieving up to 19,200 baud.
- A comprehensive radio frequency utilization plan has been developed and FCC license applications submitted. A frequency diversity approach to higher radio availability is being proposed.

Radio Frequency Deployment Options





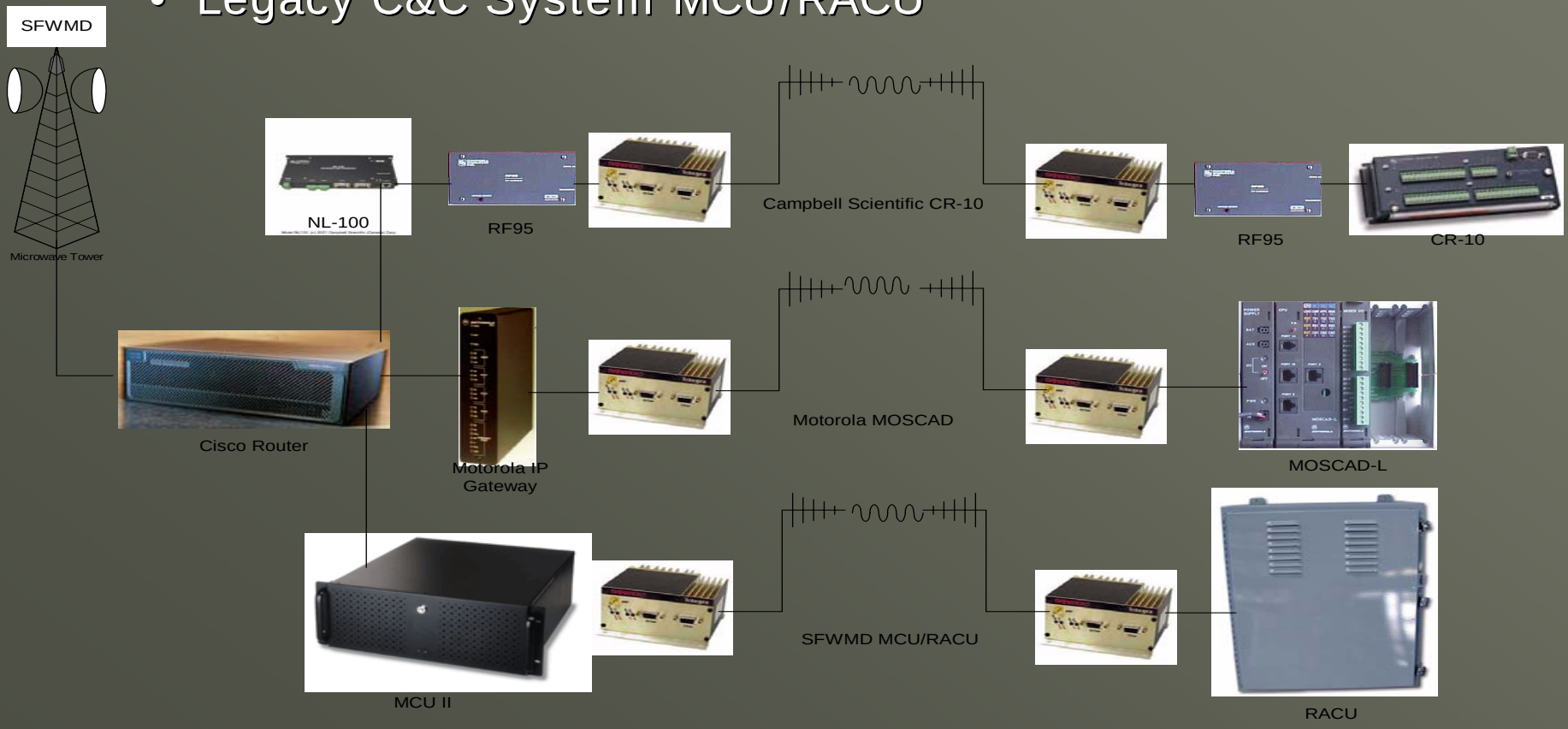
- Two telemetry redundancy options for RF use are space diversity and frequency diversity
  - Space diversity uses the same frequency to talk to one of two towers. (Method Availability: 99.99686 %, 1338 sec/yr unavailability)
  - Frequency diversity uses two frequencies the two different towers. (Method availability: 99.99999963 %, 0.11 sec/yr unavailability)
  - The frequency diversity option greatly increases the RTU availability while interference immunity increases significantly.

Microwave Transport

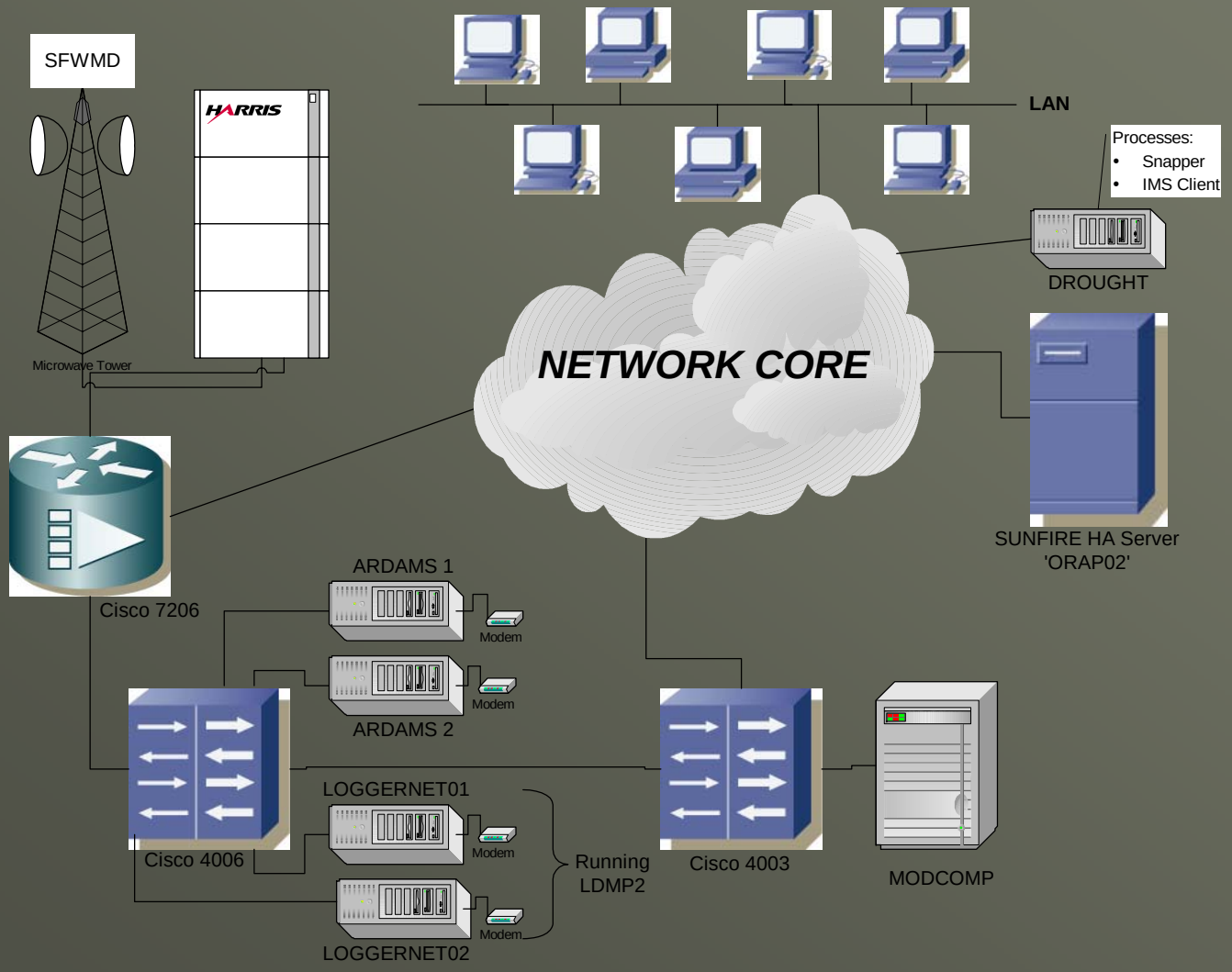
- The District owns and operates an extensive high capacity, high availability microwave infrastructure.
- The District recently (CY2003) completed the conversion of the microwave network from analog to digital technology
- The new digital backbone utilizes OC-3 (155 Mbps) SONET technology.
- The microwave towers and shelters are designed to withstand Category 4 Hurricanes (up to 155 mph).
- “Last Mile” applications use Spread Spectrum based microwave radios and provide connectivity to remote pump stations and service centers.
- The microwave network transports analog circuits, telephone circuits and data circuits (including TCP/IP) traffic.
- There are more than 35 remote sites inter-connected by microwave on the District’s Wide Area Network (WAN).

SFWMD Telemetry Network

- Three types of Remote Terminal Units are used within the SCADA system.
  - Campbell Scientific CR-10
  - Motorola MOSCAD
  - Legacy C&C System MCU/RACU



HQ Telemetry Network



Why Choose Microwave?

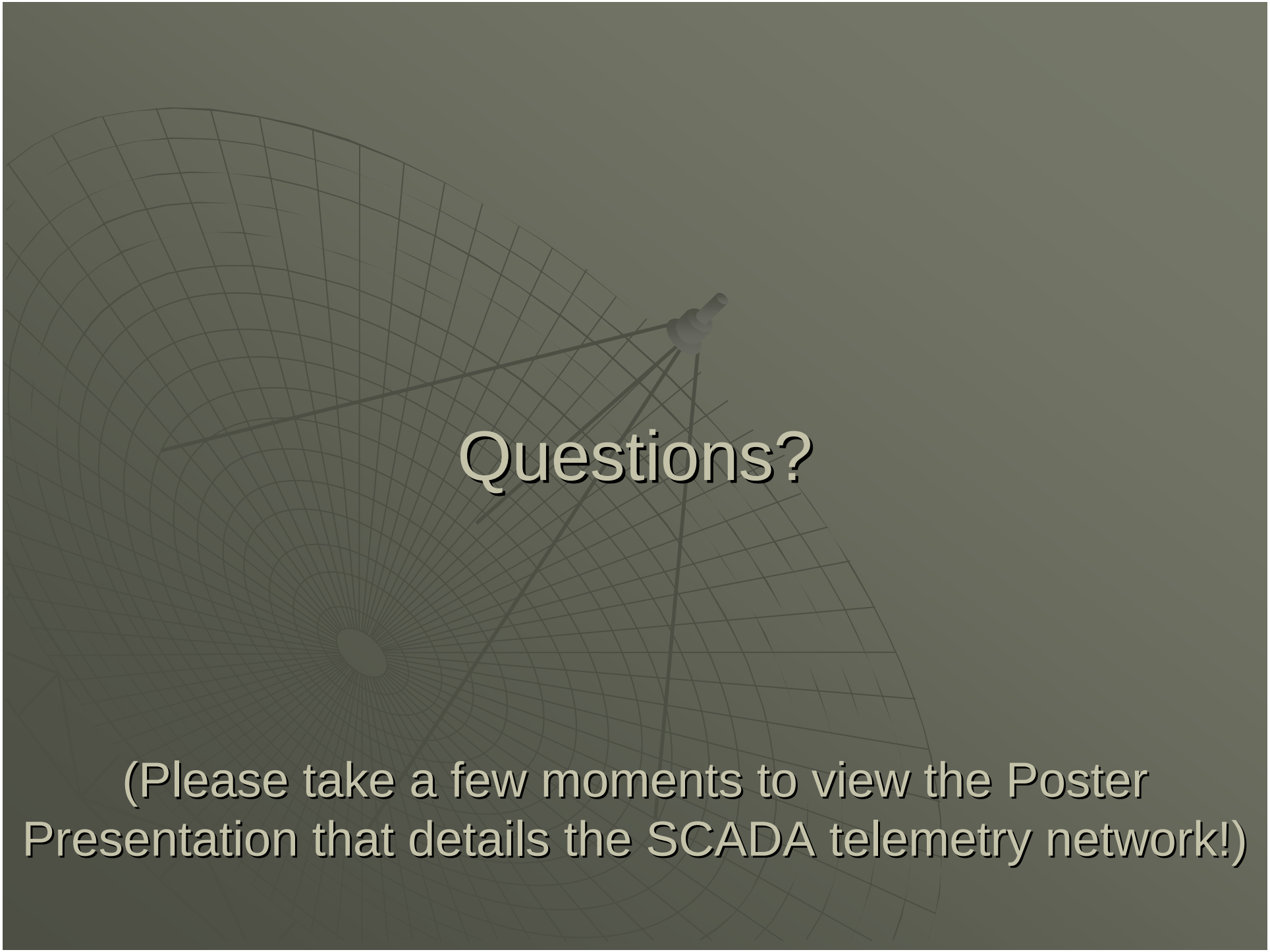
- Both Microwave and Optical transports were considered and evaluated by the District.
- Findings:
  - Fiber optic solution cost more since very high bandwidth was not a requirement.
  - Even with fiber optics a repeater every 20 miles and a tower are required for reliable RF coverage.
  - RF and microwave share and coexist on the same infrastructure.
  - Fiber Optic networks experience longer outages than microwave links as repairs can take days to weeks.
  - In summary, for our application microwave was cheaper and more reliable than fiber optics.

Availability and Reliability

- Due the District's dependency on the telemetry systems to provide flood protection. The telemetry systems needs to operate reliably and offer high availability.
- Typical Transport Link Availability
  - Leased Lines >= 99.85% (13 hours/year)
  - Optical Links >= 99.5% (MTTR can be very long)
  - Satellite Uplinks >= 99.7% (atmospheric limitations)
  - SFWMD Microwave >= 99.99975% (< 70 secs/year)

The Future of Telemetry?

- Satellite (Bent Pipe) Technologies show some emerging promise to offer cost effective solutions to SFWMD data collection needs.
- The District just completed its microwave conversion to Digital technology and is currently working to converge all data and voice applications onto TCP/IP.
- Soon the entire TCP/IP WAN will be fully meshed on top of a SONET topology making the reliability of the WAN be in excess of 99.999%.
- Once converged, every remote system will benefit from the high availability TCP/IP network. System support and network costs will be lower.
- Spread Spectrum technologies will play an increased role in the future telemetering of SCADA data and controls.



Questions?

(Please take a few moments to view the Poster Presentation that details the SCADA telemetry network!)